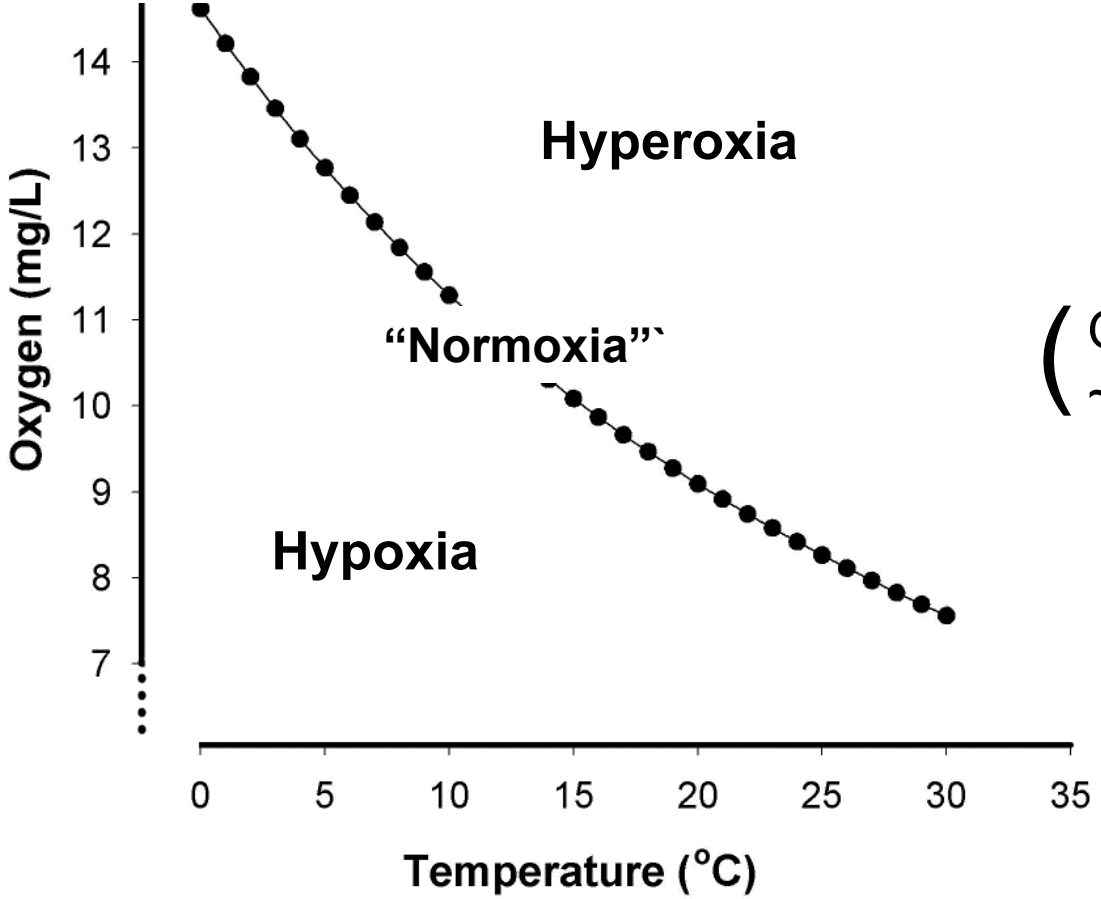
Effects of hypoxia on freshwater mussels

Brianna Kaiser and Chris Barnhart
Missouri State University

Factors affecting dissolved oxygen (DO)

- Temperature
- Sources: aquatic photosynthesis, reaeration
- Sinks: metabolism and chemical oxidation in water (BOD) and in sediment (SOD)
- Groundwater/surface water mixing
- Hypolimnetic release from reservoirs

DO in air-saturated water vs. temperature

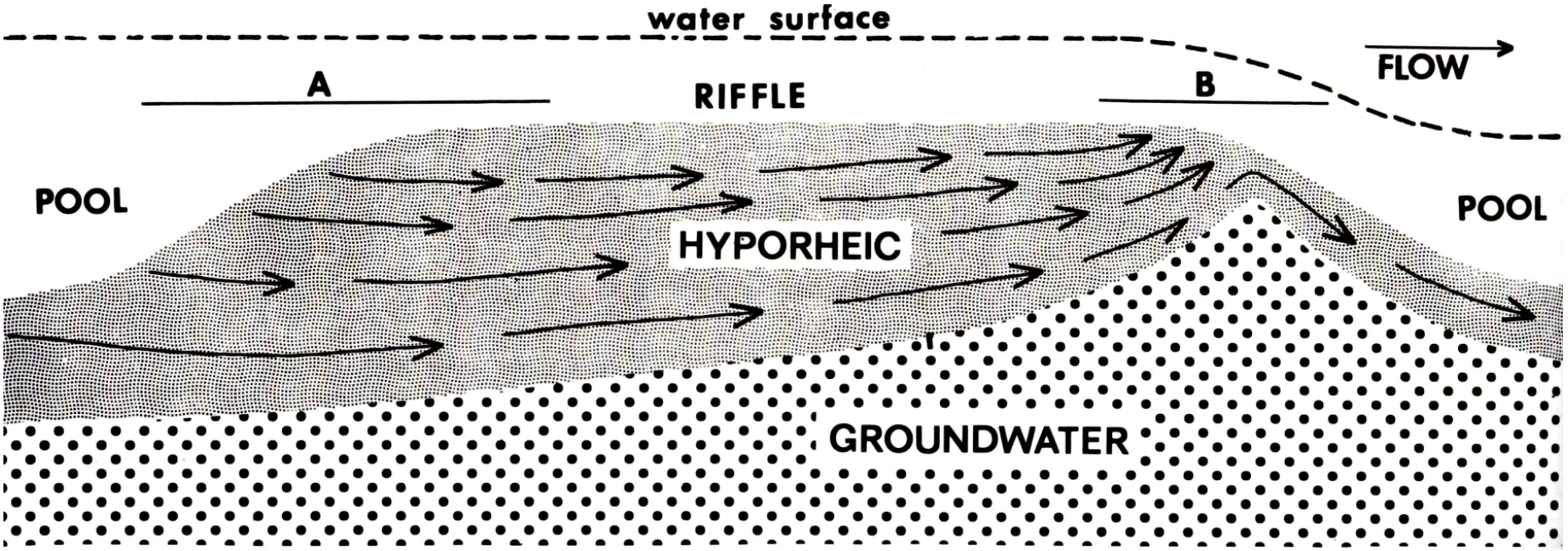


(Oxygen in air: ~300 mg O_2 / L)

DO in stream beds

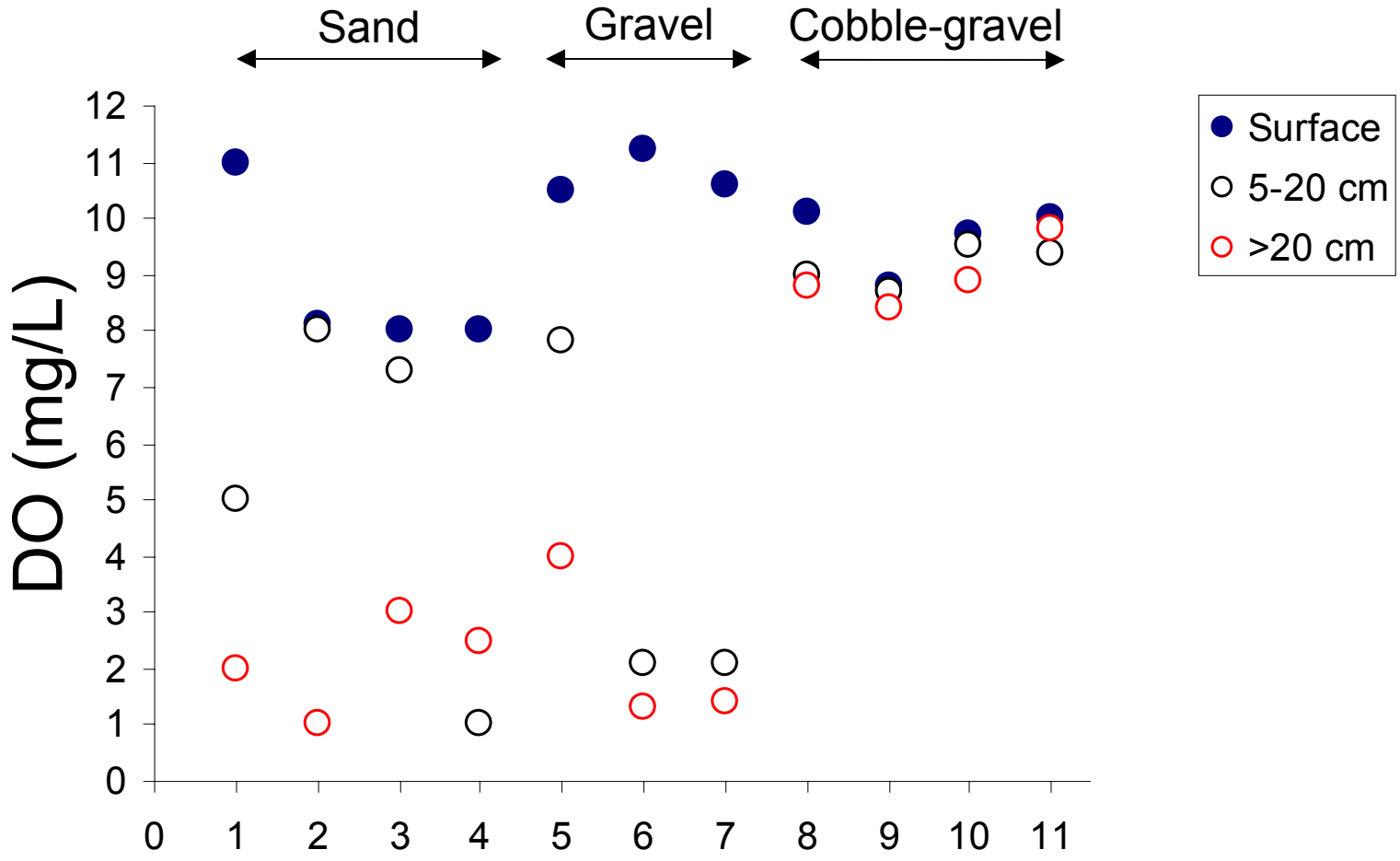
- Mussels burrow to variable depth and are exposed to interstitial water.
- Hyporheic DO is lower and more variable than water column DO
- Influences include flow, sediment particle size, SOD

Water movement through hyporheic zone of a streambed



A: downwelling B: upwelling

DO vs depth and particle size in streambeds



11 studies reviewed by Mallard & Hervant (1999)

Sediment D.O. at 1 cm depth along 3 transects in a prairie stream in Kansas (arrows = anoxia)

Kemp & Dodds 2001 JNABS

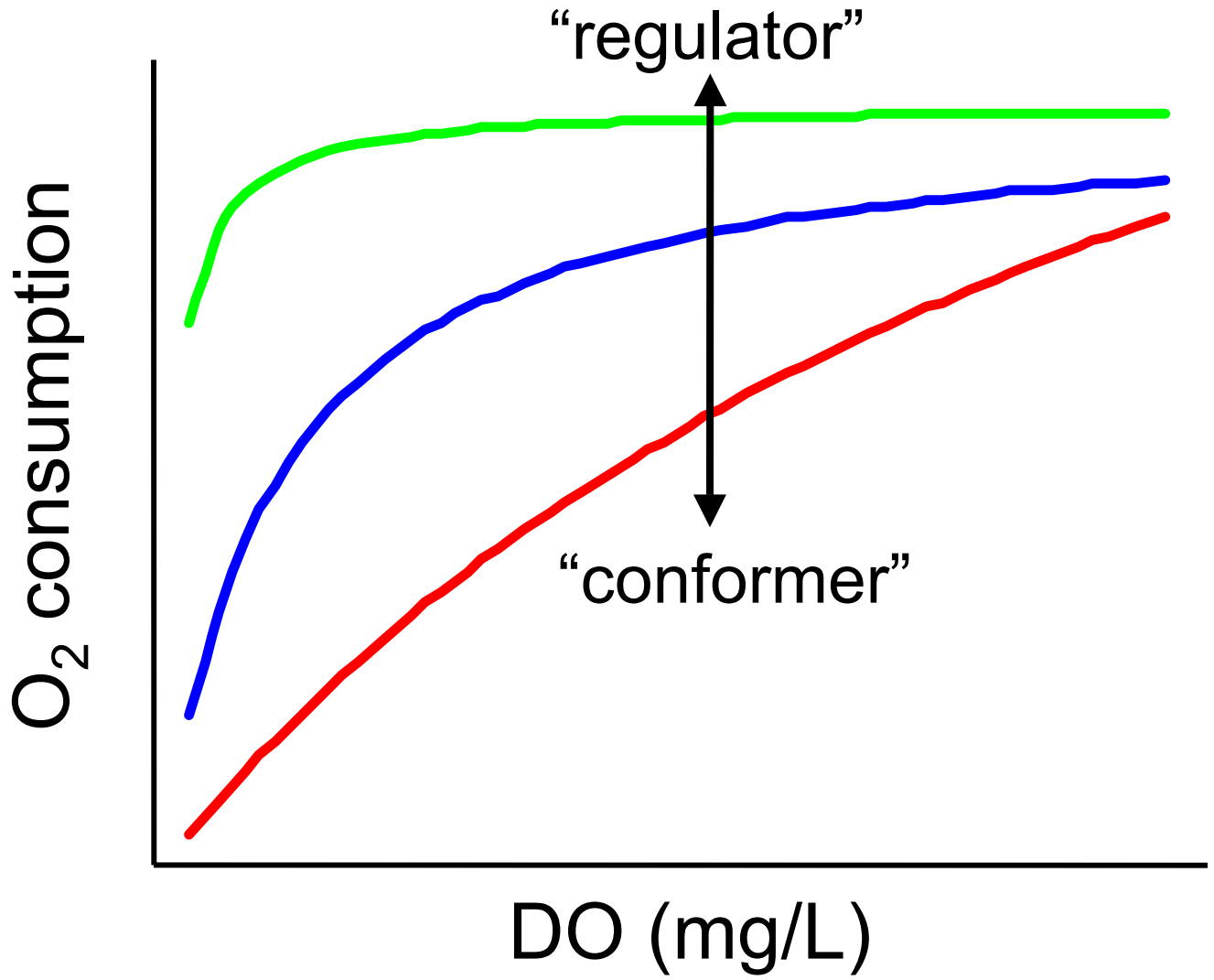
Where are the mussels?

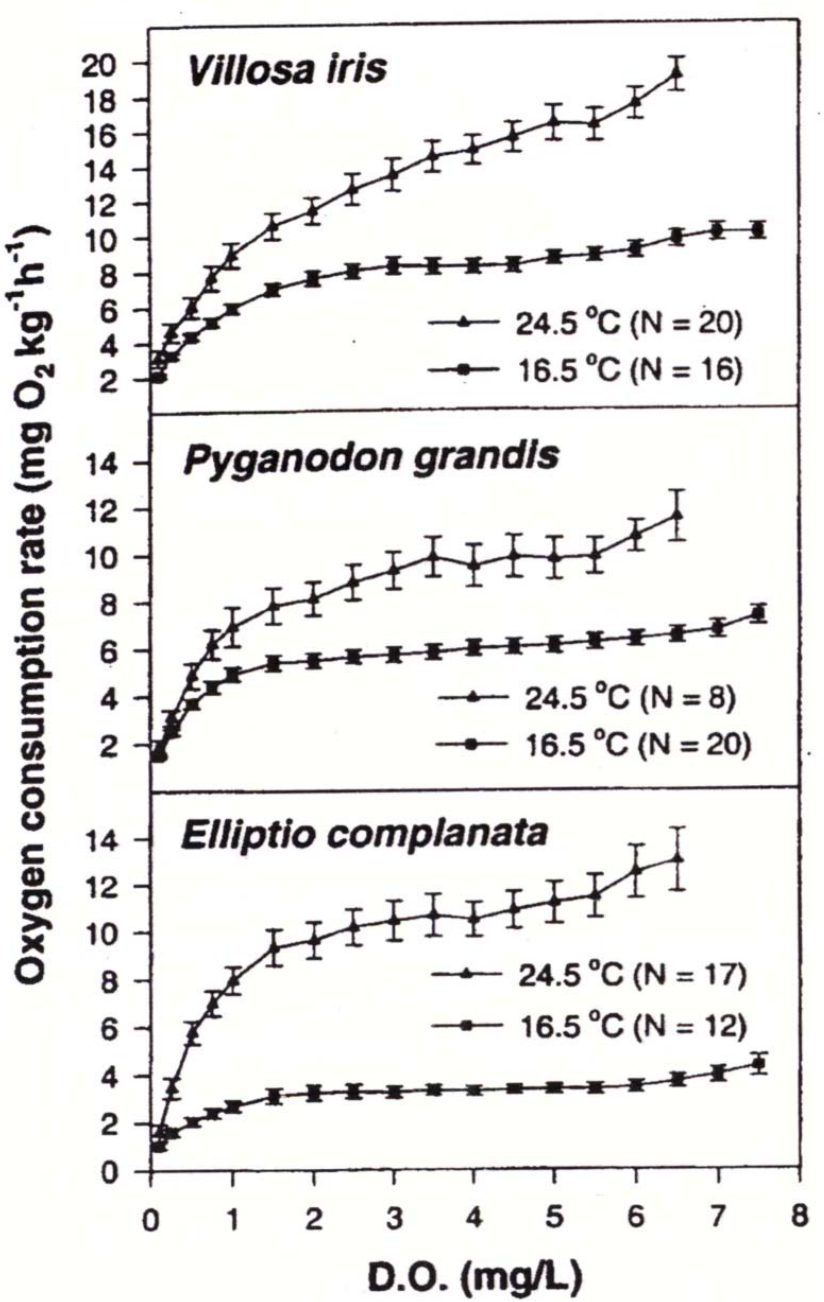
- Adults generally keep siphons at the sediment surface but may bury up to 5-10 cm below surface.
- Young juveniles are interstitial meiofauna that burrow 1 to several cm deep (Neves & Widlack 1987, Yeager, Cherry & Neves 1994)
- Adult and juvenile mussels are potentially affected by both interstitial and water column DO

Effects of hypoxia

- Limitation of aerobic metabolism (MO_2)
- Reduced growth rate
- Behavioral responses
- Mortality

Patterns of DO limitation of MO_2





Effect of DO and temperature on MO_2 of adult unionids.

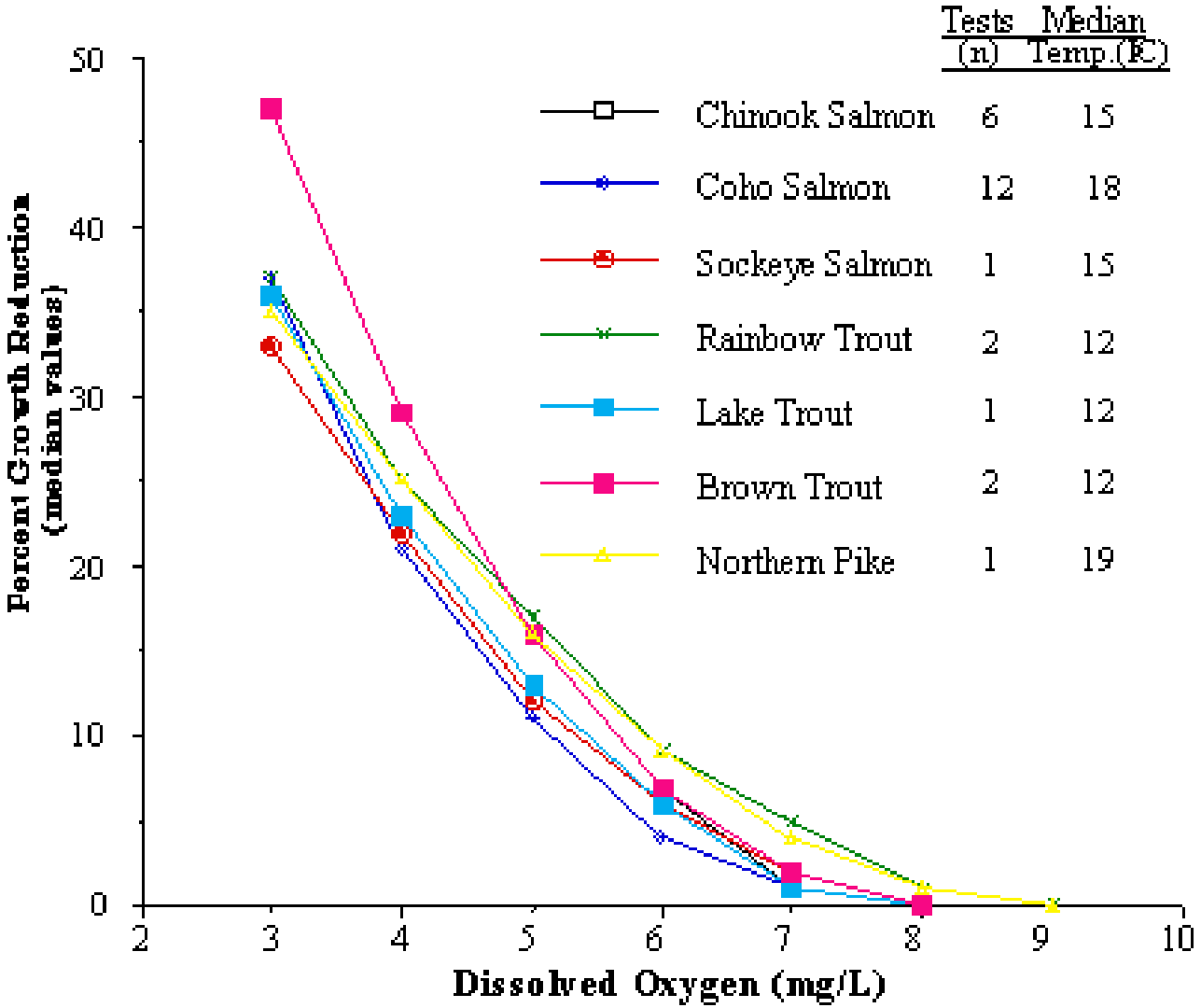
- Better regulation at lower temperature
- Species/habitat differences

Chen et al. 2001

Effects of hypoxia

- Limitation of aerobic metabolism (MO_2)
- **Reduced growth rate**
- Behavioral responses
- Mortality

Salmonid growth vs. DO



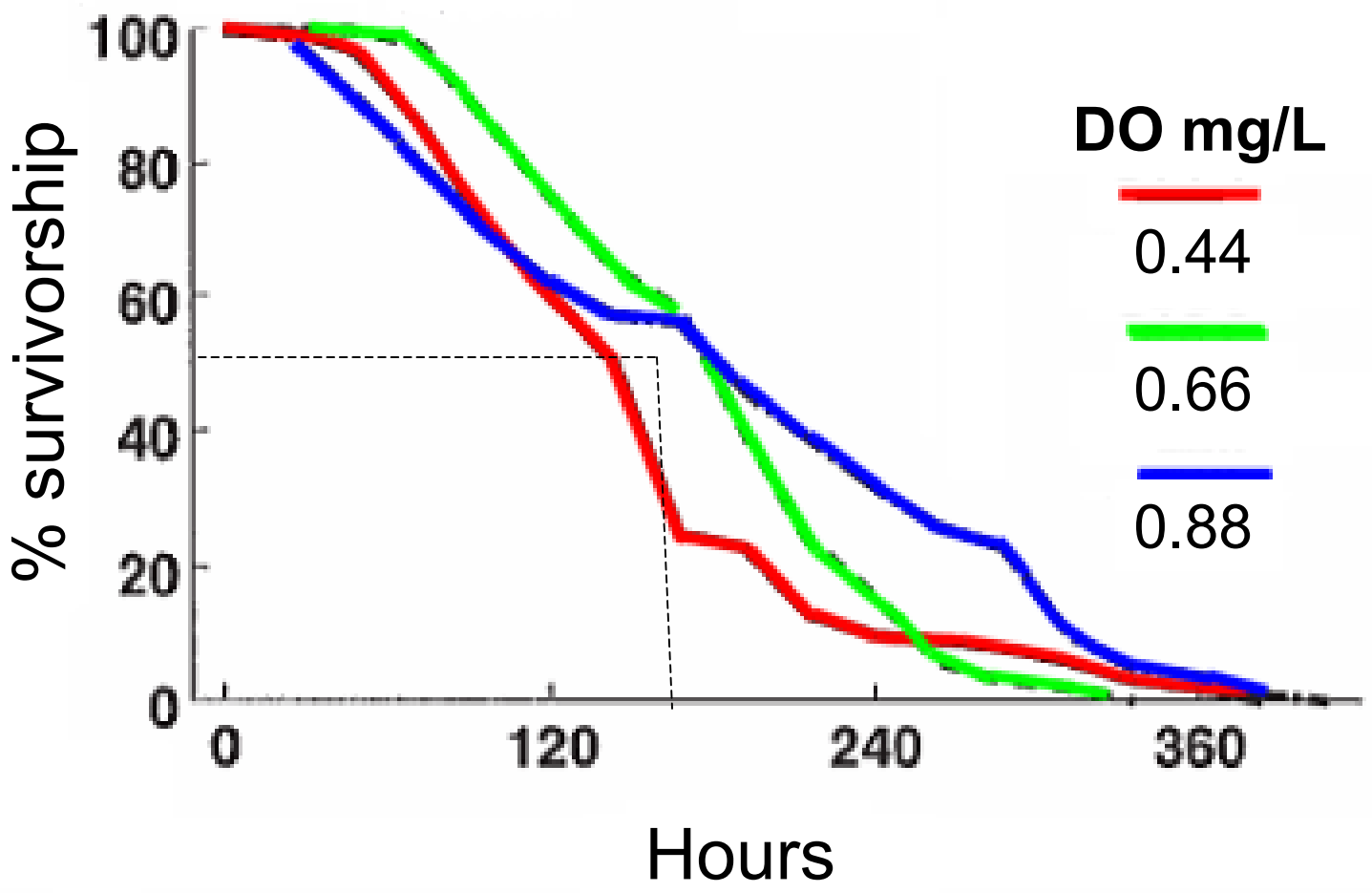
Behavioral responses to hypoxia
(Sparks and Strayer 1998 - *Elliptio*)

- Increased siphon extension
- Gaping
- Would not bury as deep
- Moved closer to the water inlet

Effects of hypoxia

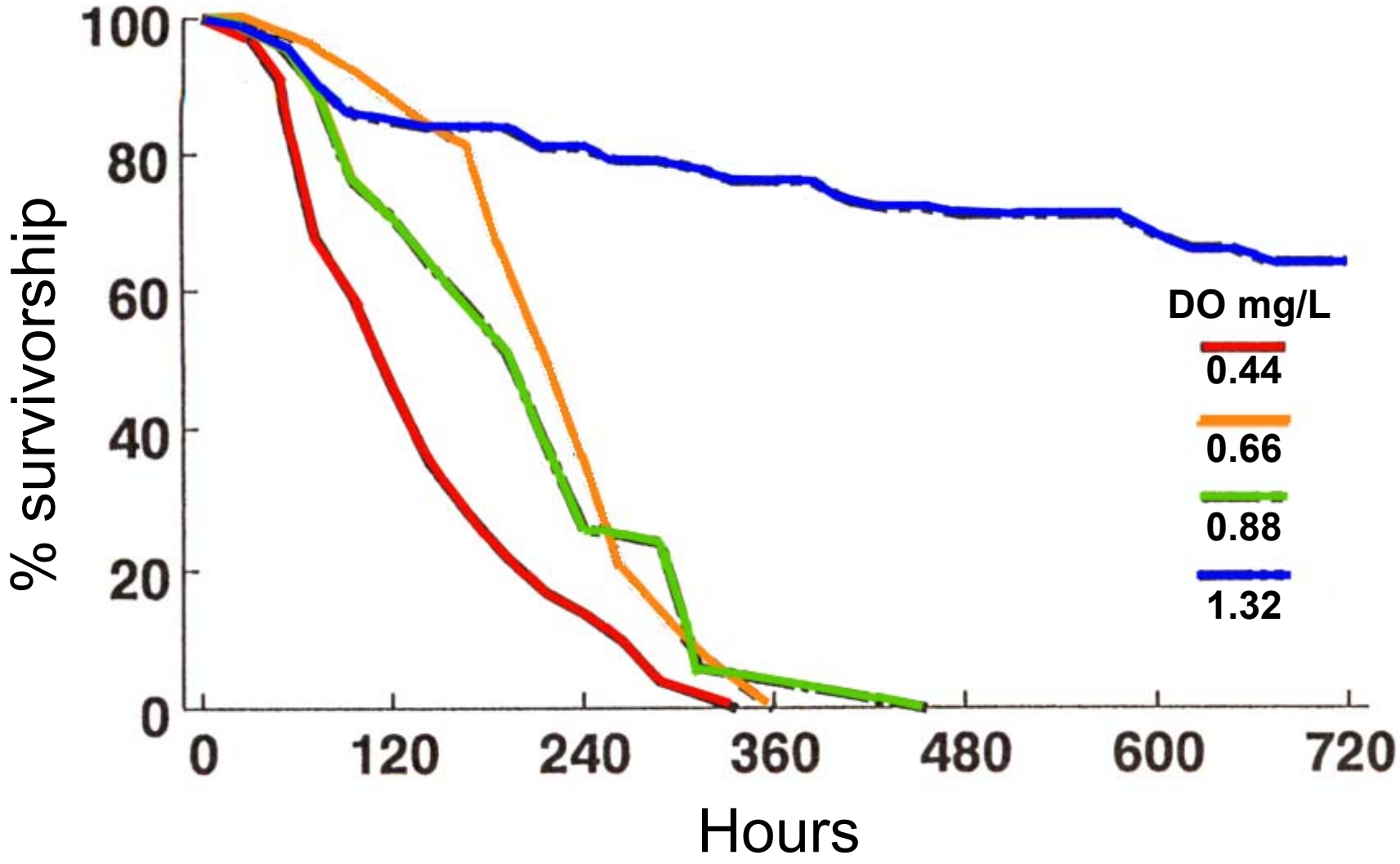
- Limitation of aerobic metabolism (MO_2)
- Reduced growth rates
- Behavioral responses
- Mortality

Survivorship of *Corbicula fluminea* in chronic hypoxia (25° C)



Johnson and McMahon 1998

Survivorship of *Dreissena polymorpha* in chronic hypoxia (25° C)



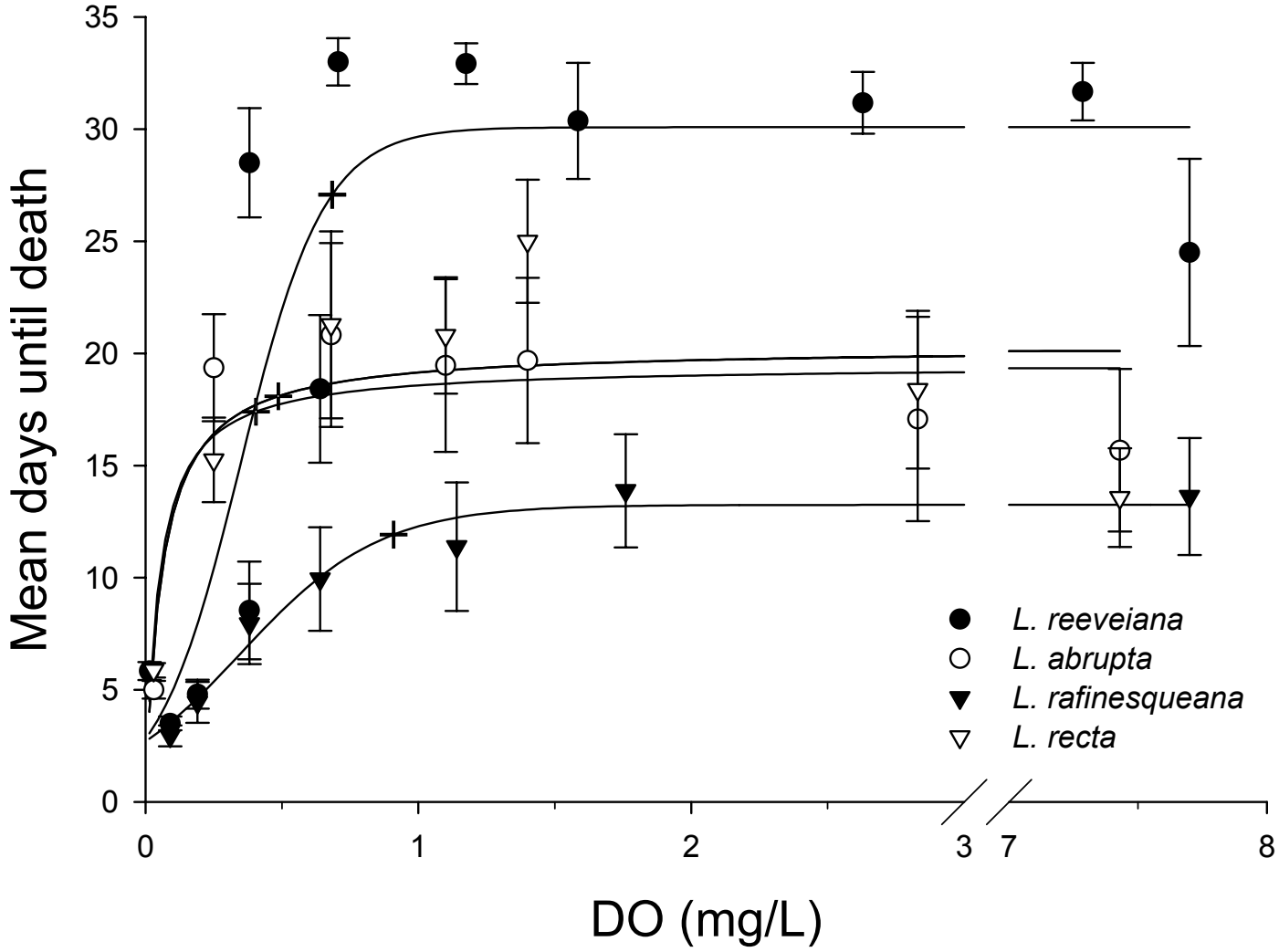
Johnson and McMahon 1998

Survival of juvenile unionids in chronic hypoxia

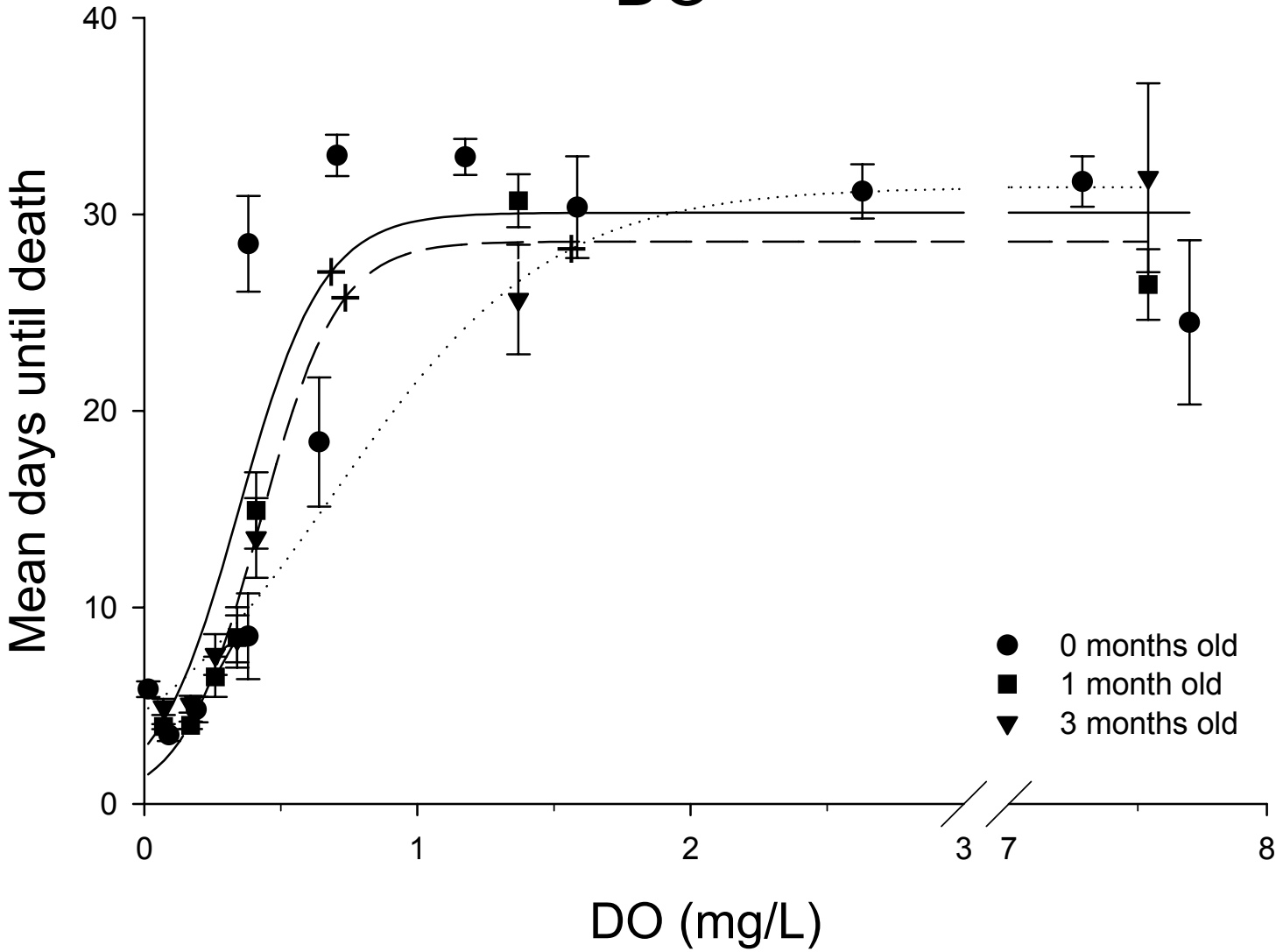
- 4 species of juveniles (0 to 3 mo) were exposed to hypoxia for up to 49 d at 20°C
- Juveniles were not fed
- Survival was assessed at 2-d intervals
- Determined mean days-death vs. DO

Regulating DO in the lab

Survival of 4 species of unionid juveniles vs. DO



Survival of 3 age classes of *L. reeveiana* vs. DO



Planned studies

- Hypoxia effects on growth of juveniles
- Influence of temperature on hypoxia tolerance
- Hypoxia tolerance of brooding females and brooded embryos

Marsupial gills

Gravid outer gill of flat floater
(*Anodonta suborbiculata)*

Gravid outer gill of squawfoot
(*Strophitus undulatus)*

Hypoxia effects on brooding females and brooded embryos

- Marsupial gills are massive and may be poorly ventilated.
- Developing embryos in other aquatic species are typically highly sensitive to low DO.
- Females of some mussel species abort developing embryos when exposed to hypoxia.

Summary

- Mussels are exposed to interstitial water, where DO is often much lower than in the water column, where it is typically measured
- Adult mussels have limited ability to regulate oxygen consumption in hypoxia.
- DO LC_{50} and LT_{50} studies of unionids are lacking
- Young juvenile unionids showed reduced survival time below ~1mg/L at 20^{o} C

Summary, continued

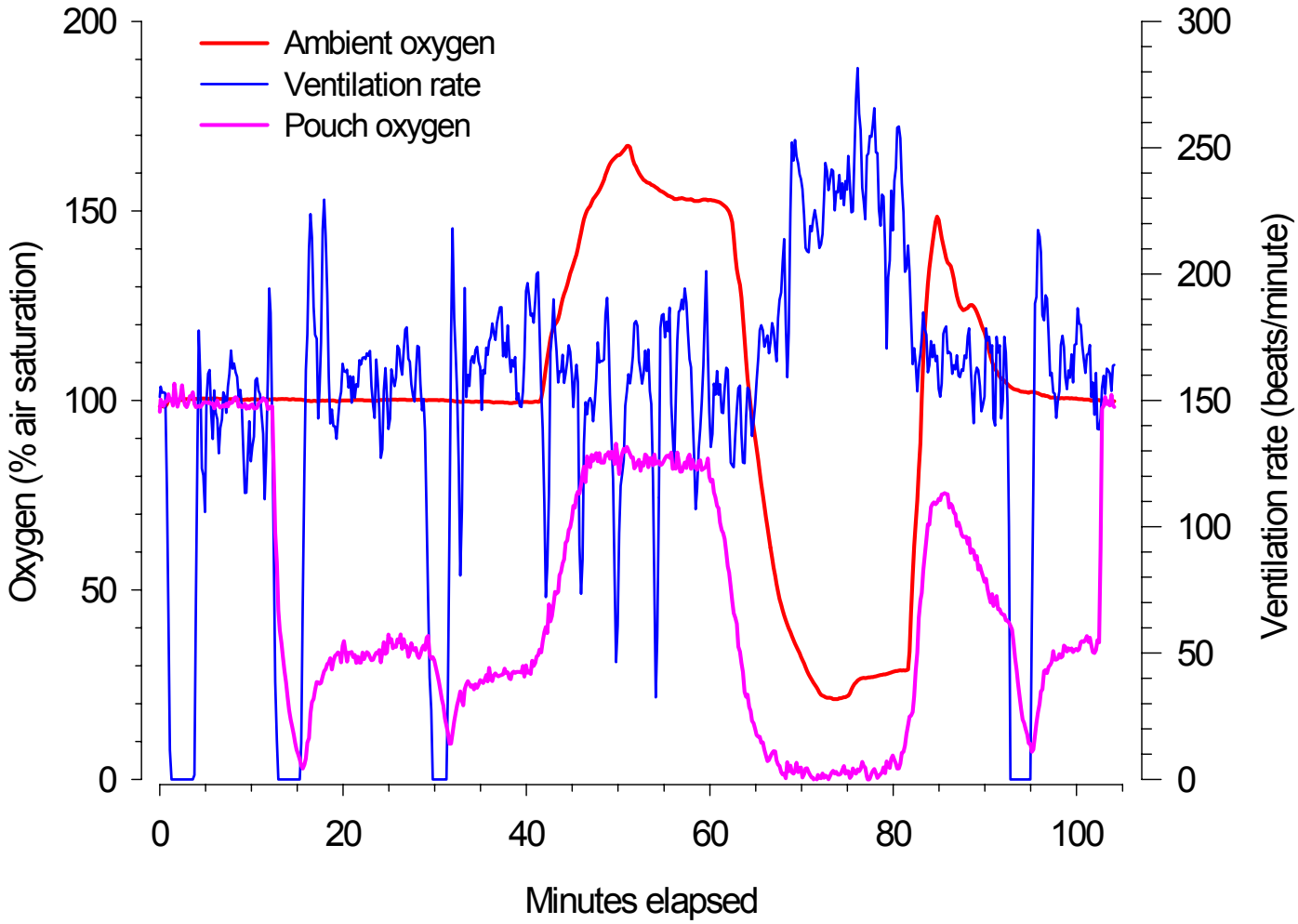
- Hypoxia effects on growth and reproduction have not been studied.
- Brooding females and developing embryos could be particularly susceptible to hypoxia.

Questions?

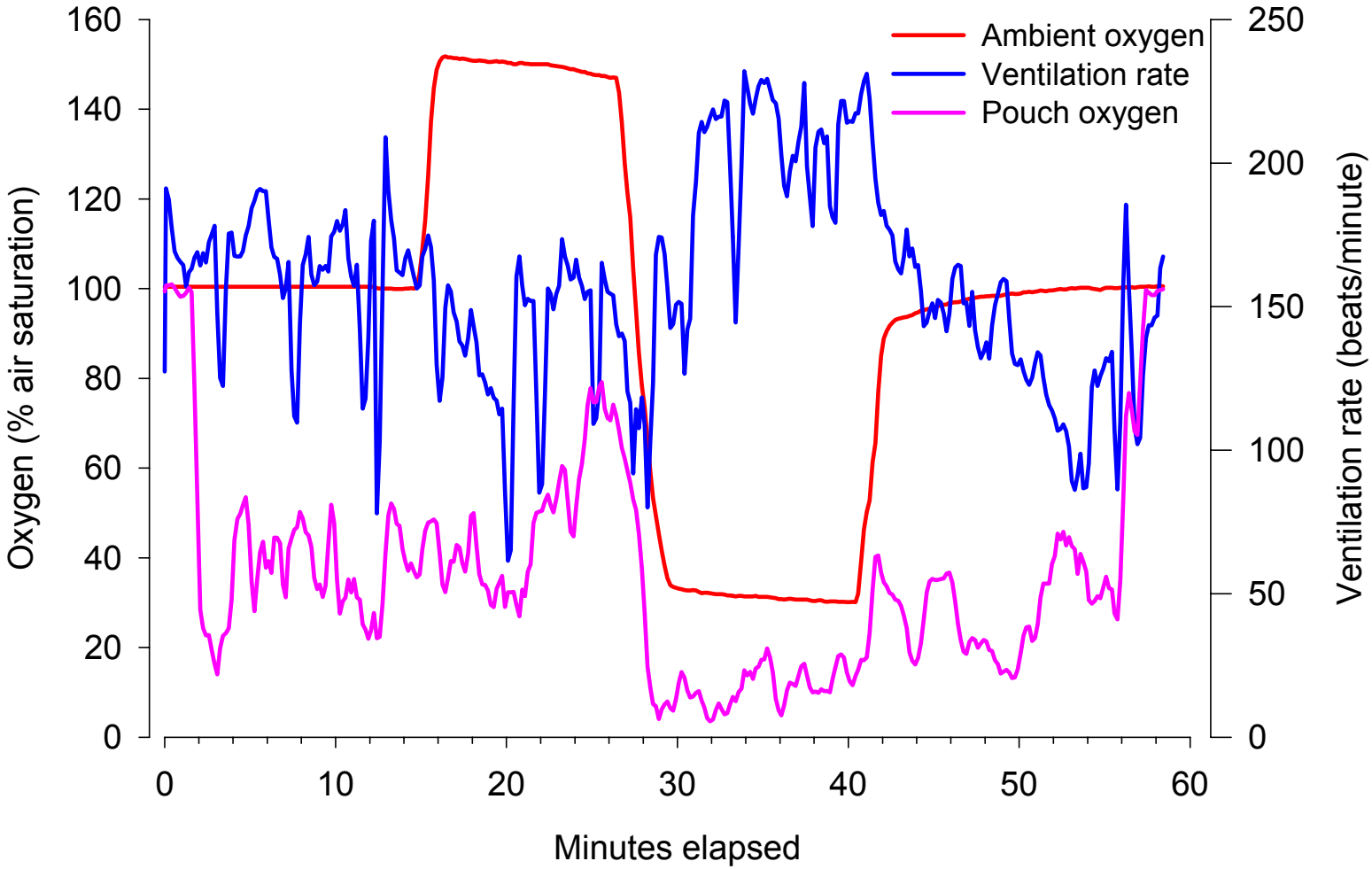
Environmental evidence

- Buddensiek *et al.* (1993) found negative correlation of juvenile unionid distribution with sediment hypoxia
- Rebound of Unionids in Duck River after improvement of DO below Normandy Dam

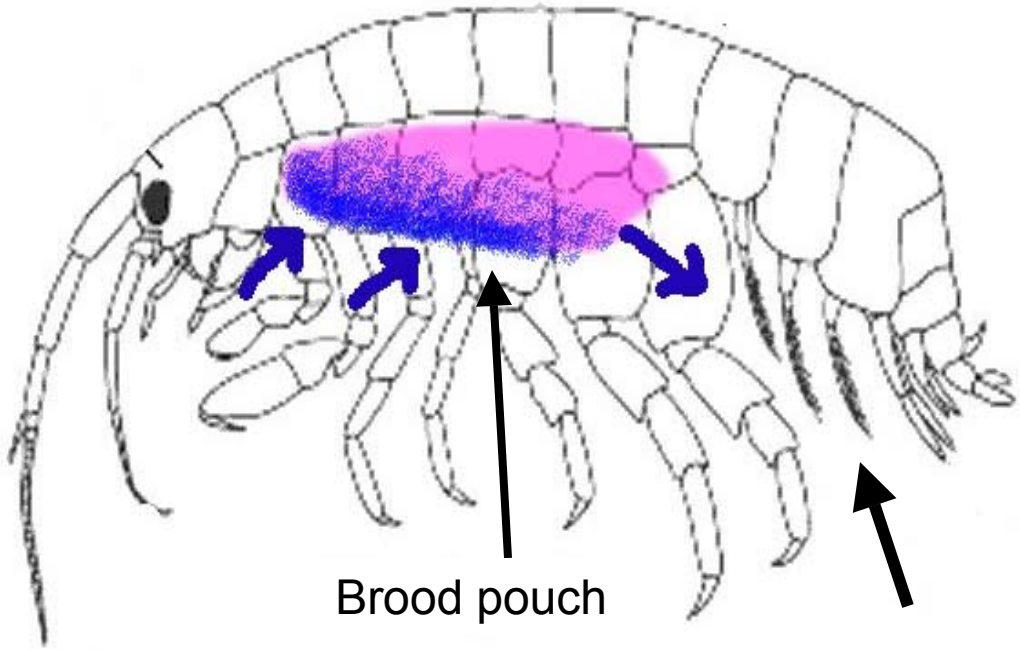
Effect of ambient oxygen on ventilation rate and brood pouch oxygen.
Embryos stage A-B.



Effect of ambient oxygen on ventilation rate and brood pouch oxygen.
Hatchlings.



Brooding amphipod



Oxygen vs depth in marsupium (38 stage C embryos)